Visual Alignment

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Intro to Visual Alignment Program (visualign)

- Purpose
- Event reconstruction
- Track selection
- Alignment procedure
- Displaying residuals at step
- Alignment step options

Purpose

- Visualize alignment problems
  - 3D residuals
  - Display selected residuals
- Develop alignment strategies graphically
  - Selection of alignment objects / parameters
  - Selection of tracks to use
  - Specification of sequence of such alignments
- Record strategy for reuse and modification
- Align all DØ detectors

Event Reconstruction

- Load Mutable Offline Geometry
- Must redo Reco after each alignment step
- Local clusters do not need redo
- Repeatedly run D0Reco with I,O files?
- Save stripped down events in memory?
- Call D0Reco from alignment program?

Track Selection

- Tracks with p_t > say 5 GeV/c for barrel
- Tracks with high p_z for disks (minbias?)
- Might use several samples at once.
- Do we need special triggers?
- Multiple tracks vertexed to interaction?

Alignment Procedure

- Reconstruct events
- Select objects / geometry transforms
- Select components of transforms
- Select track sample(s)
- Display residuals
- Try step, accept or reject it
- Repeat above until alignment done

Displaying Residuals at Step

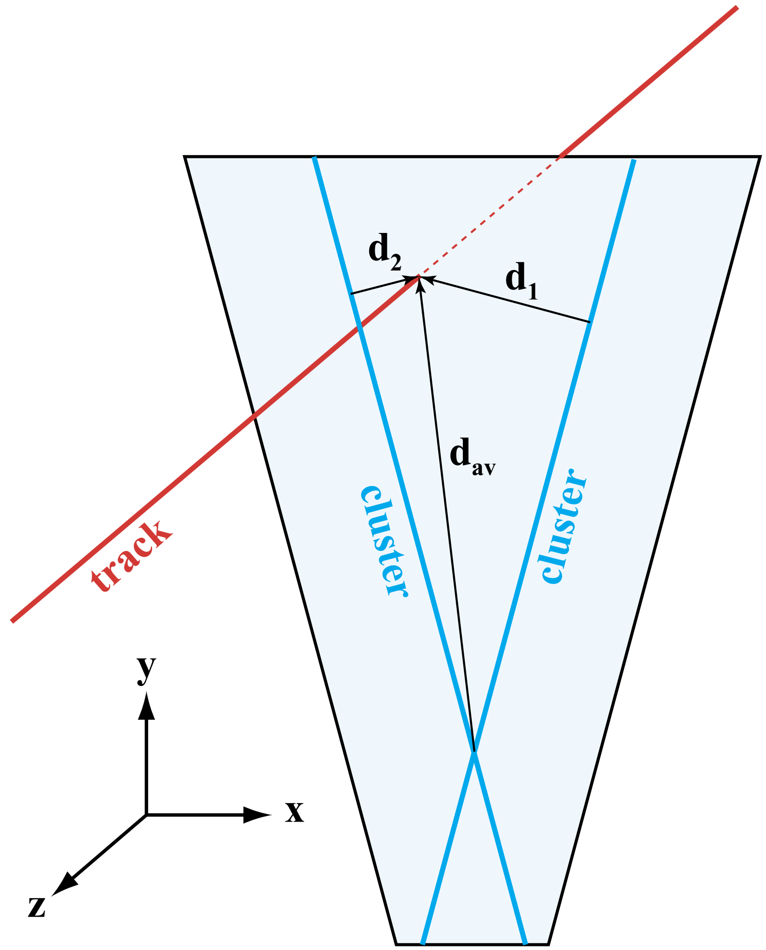
- Display 3D vectors (with error ellipse?)
- Cut on significance, e.g. 3 sigma from zero
- At each alignment step:
  - Display selected objects / transforms
  - Display selected track sample(s)
  - Display related residual field
  - Display χ^2 , Rot, Trans for each transform

Alignment Step Options

- Try this alignment step
  - Rot, Trans to obtain minimum χ^2
  - Display Residuals after this step
  - Either: Reject this step
    - Back up to selections for this step
  - Or: Accept this step
    - Log selections for this step
    - Begin selections for next step
- Manually move object; view χ^2 , Rot, Trans

Progress on visualign

- 3D residual concept tested
- Some Classes written, in CVS
  - Residual
  - SMTResidual (prototype XXXResidual)
  - ResidualField written
- Trying to read events
- Immediate goal: Display some residuals
- Longer term goal: Align 10% test



track
cluster
cluster
d2
d1
dav
y
x
z

The $\chi^2(\mathbf{Q},\mathbf{h})$ that $\mathbf{d}_i'$, the residuals after rotation $\mathbf{R}$ $(\mathbf{Q}=\mathbf{R}-\mathbf{1})$ and translation $\mathbf{h}$, are equal to zero within their error matrices $\mathbf{E}_\mathbf{i}$ is

$$\chi^2(\mathbf{Q},\mathbf{h}) = \sum_{\mathbf{i}} \mathbf{d}_\mathbf{i}'^\dagger \mathbf{E}_\mathbf{i}^{-1}\mathbf{d}_\mathbf{i}',$$

$$\mathbf{d}_\mathbf{i}' = \mathbf{d}_\mathbf{i} - \mathbf{Q}\mathbf{s}_\mathbf{i} - \mathbf{h},$$

$$\mathbf{Q} = \mathbf{R} - \mathbf{1}.$$

$\mathbf{d}_\mathbf{i}$ is residual
$\mathbf{t}_\mathbf{i}$ is track
$\mathbf{s}_\mathbf{i}$ is cluster

$$\begin{aligned} \mathbf{d}_\mathbf{i} &= \mathbf{t}_\mathbf{i} - \mathbf{s}_\mathbf{i} \\ \mathbf{s}_\mathbf{i}' &= \mathbf{R}\mathbf{s}_\mathbf{i} + \mathbf{h} \\ \mathbf{d}_\mathbf{i}' &= \mathbf{t}_\mathbf{i} - \mathbf{s}_\mathbf{i}' \\ &= \mathbf{d}_\mathbf{i} + \mathbf{s}_\mathbf{i} - \mathbf{s}_\mathbf{i}' \\ &= \mathbf{d}_\mathbf{i} + \mathbf{s}_\mathbf{i} - \mathbf{R}\mathbf{s}_\mathbf{i} - \mathbf{h} \\ &= \mathbf{d}_\mathbf{i} - (\mathbf{R} - \mathbf{1})\mathbf{s}_\mathbf{i} - \mathbf{h} \\ &= \mathbf{d}_\mathbf{i} - \mathbf{Q}\mathbf{s}_\mathbf{i} - \mathbf{h} \end{aligned}$$

Differentiating χ^2 .with respect to the components of $\mathbf{Q}$ and $\mathbf{h}$ and setting the differentials equal to zero yields six equations in the components of $\mathbf{Q}$ and $\mathbf{h}$**:**

$$\sum_{m=1}^{3} a_{jm}\theta_m + \sum_{n=1}^{3} b_{jn}h_n = c_j, \qquad \text{j=1,3,}$$

$$\sum_{m=1}^{3} d_{jm}\theta_m + \sum_{n=1}^{3} e_{jn}h_n = f_j, \qquad \text{j=1,3,}$$

$$a_{jm} = \sum_i \mathbf{s}_\mathbf{i}^\dagger \mathbf{Q}_\mathbf{j}^\dagger \mathbf{E}_\mathbf{i}^{-1}\mathbf{Q}_\mathbf{m}\mathbf{s}_\mathbf{i}, \quad b_{jn} = \sum_i \mathbf{s}_\mathbf{i}^\dagger \mathbf{Q}_\mathbf{j}^\dagger \mathbf{E}_\mathbf{i}^{-1}\mathbf{u}_\mathbf{n}, \quad c_j = \sum_i \mathbf{s}_\mathbf{i}^\dagger \mathbf{Q}_\mathbf{j}^\dagger \mathbf{E}_\mathbf{i}^{-1}\mathbf{d}_\mathbf{i},$$

$$d_{jm} = \sum_i \mathbf{u}_\mathbf{j}^\dagger \mathbf{E}_\mathbf{i}^{-1}\mathbf{Q}_\mathbf{m}\mathbf{s}_\mathbf{i}, \qquad e_{jn} = \sum_i \mathbf{u}_\mathbf{j}^\dagger \mathbf{E}_\mathbf{i}^{-1}\mathbf{u}_\mathbf{n}, \qquad f_j = \sum_i \mathbf{u}_\mathbf{j}^\dagger \mathbf{E}_\mathbf{i}^{-1}\mathbf{d}_\mathbf{i}.$$

Assuming no rotation, the translation vector $\mathbf{h}$ which minimizes χ^2 is

$$\mathbf{h} = \left(\sum_{\mathbf{i}} \mathbf{E}_\mathbf{i}^{-1}\right)^{-1} \sum_{\mathbf{i}} \mathbf{E}_\mathbf{i}^{-1}\mathbf{d}_\mathbf{i},$$

which is the weighted average of the residuals, where the weighting includes the effects of correlations.